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SPECIFICATION

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Program - Project - Job: LHC IR Feedbox (DFBX)
Cryogenics

Title: DFBX Chimney Bellows

REVISION RECORD

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1. Scope

This specification establishes the requirements for the design, manufacture, test, and packaging of multi-ply bellows to be used in the fabrication of the current lead chimneys for the LHC IR Cryogenic Feedboxes, designated as DFBX. Two types of multi-ply bellows are specified, Type I and Type II. Type I bellows are used in a cryogenic environment and Type II bellows are used in ambient conditions.

2. Applicable Documents

2.1 Standards of the Expansion Joint Manufacturers Association, 1998 edition
2.2 ASME Boiler and Pressure Vessel Code, sec IX, current edition.
2.3 ASTM E498, "Standard Test Methods for Leaks Using the Mass Spectrometer Leak Detector or Residual Gas Analyzer in the Tracer Probe Mode", current edition.

3. Requirements

3.1 Type I Bellows Design Requirements satisfy EJMA Standards
- 3.1.1 Bellows operating temperature: Room Temperature to 4.2 K (100 °F to -452 °F)
- 3.1.2 Bellows design pressure: 70 psig (4.8 bar gauge) internal
- 3.1.3 Bellows test pressure: 100 psig (6.9 bar gauge) internal
- 3.1.4 Operating Fluid: Helium
- 3.1.5 External conditions: air at ambient pressure and temperature to UHV
- 3.1.6 Axial Travel: 0.09 inch extension (2.3 mm extension) from neutral position
- 3.1.7 Axial Spring rate: 845 lb/inch (0.15 MN/m) ±10%
- 3.1.8 Lateral Offset: 0.12 inch (2.3 mm) from neutral position
- 3.1.9 Lateral Spring Rate: 5170 lb/inch (0.9 MN/m) ±10%
- 3.1.10 Fatigue Lifetime: 1000 cycles with simultaneous application of 3.1, 3.2, 3.6, and 3.8
- 3.1.11 Number of Convolutions: 8

3.2 Type I Bellows Physical Requirements
- 3.2.1 Overall length: 4 ± 0.06 inch (includes weld cuffs in 3.2.5) in neutral position
- 3.2.2 Convolution Minimum Inner Diameter: 5.84 ± .020 inch
- 3.2.3 Convolution Maximum Outer Diameter: 6.64 ± 0.02 inch
- 3.2.4 Convolution Configuration
  - 3.2.4.1 3 ply,
  - 3.2.4.2 Material: A240-T316L
  - 3.2.4.3 Outer 2 plys are ventilated to prevent trapping of liquid helium between the plies
    - 3.2.4.3.1 Vent holes to be approx 0.06 inch in diameter
    - 3.2.4.3.2 Vent holes to be positioned on the sides of each convolution
    - 3.2.4.3.3 Vent holes to be arranged at 4 places, equally spaced, on each convolution flat side
    - 3.2.4.3.4 Vent holes do not have to line up with each other

3.2.4.3.5 Vent holes to be deburred prior to bellows formation

3.2.5 Weld Cuff

3.2.5.1 Weld Cuff on both ends, 0.25 inch long each end past weld to convolutions

3.2.5.2 Weld Cuff Outer Diameter: 6.000 (+.000, -.010) inch

3.2.5.3 Weld Cuff Wall Thickness: .080 ± .010 inch

3.2.5.4 Weld Cuff Material: A240-316L

3.3 Type II Bellows Design Requirements satisfy EJMA Standards

3.3.1 Bellows operating temperature: Room Temperature

3.3.2 Bellows design pressure: 50 psig (3.5 bar gauge) internal

3.3.3 Bellows test pressure: 65 psig (4.5 bar gauge) internal

3.3.4 Operating Fluid: Helium gas

3.3.5 External conditions: air at ambient pressure and temperature

3.3.6 Axial Travel: 0.6 inch extension and compression from neutral position

3.3.7 Axial Spring rate: 1275 lb/inch (0.22 MN/m) ±10%

3.3.8 Lateral Offset: 0.049 inch (1.2 mm)

3.3.9 Lateral Spring Rate: 16550 lb/inch (2.8 MN/m) ±10%

3.3.10 Fatigue Lifetime: 1000 cycles with separate applications of 3.3.6 and 3.3.8

3.3.11 Number of Convolutions: 4

3.4 Type II Bellows Physical Requirements

3.4.1 Overall length: 2.5 ± 0.06 inch (includes weld cuffs in 3.4.5) in neutral position

3.4.2 Convolution Minimum Inner Diameter: 5.84 ± .020 inch

3.4.3 Convolution Maximum Outer Diameter: 6.64 ± .020 inch

3.4.4 Convolution Configuration

3.4.4.1 3 ply

3.4.4.2 Material: A240-T316L

3.4.4.3 Outer plies are not ventilated

3.4.5 Weld Cuff

3.4.5.1 Weld Cuff on both ends, 0.25 inch long each end past weld to convolutions

3.4.5.2 Weld Cuff Outer Diameter: 6.000 (+.000, -.010) inch

3.4.5.3 Weld Cuff Wall Thickness: .080 ± .010 inch

3.4.5.4 Weld Cuff Material: A240-316L

3.5 Fabrication

3.5.1 Manufacturer shall use standard bellows forming methods

3.5.2 Welding shall be done in accordance with ASME Code Section IX

3.5.3 Standard shop NDE shall be performed on welds

3.5.4 Clean after fabrication with alcohol or suitable solvent; bake out Type I bellows to remove any moisture trapped between convolutions.

4. Testing

4.1 Preproduction samples: Three pre-production samples of Type I bellows shall be submitted to LBNL for examination and testing prior to beginning production.

4.2 Pressure Testing

4.2.1 Completed assemblies shall be tested to the appropriate test pressure in 3.1.3 or 3.3.3.

4.2.2 For Type I bellows, the test shall use dry nitrogen gas as the pressurizing medium.

4.2.3 For Type II bellows, either pneumatic or hydrostatic testing may be performed, at the Manufacturer's discretion. If hydrostatic testing is performed, the assemblies must be carefully cleaned and dried afterwards.

4.2.4 The bellows shall be held at test pressure for 10 minutes with the supply valve closed, and there shall be no detectable loss of pressure during this period.

4.3 Leak Testing in accordance with ASTM E498 after pressure testing

4.3.1 Leak testing shall be performed with a helium mass spectrometer type leak detector in the conventional tracer probe configuration whereby the interior of the bellows is under vacuum and connected to the leak detector. Helium gas is lightly sprayed on the outside of the bellows and in-leaks of helium are detected.

4.3.2 The leak detector shall be calibrated with a suitable leak standard.

4.3.3 The leak rate shall be less than $1x10^{-9}$ atm cc He/sec.

5. Packaging and Shipping

5.1 Material certificates and test results shall be supplied with the completed bellows

5.2 Bellows shall be sealed in a plastic bag for shipment. Type I bellows shall be packaged as soon as possible after furnace drying in 3.5.4

5.3 The plastic bag containing the bellows shall be tagged with this specification number and Type

5.4 Bellows shall be packed to prevent shipping damage